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DATA BUS TRANSMITTER
[DATENBUS-TRANSMITTER]

PETER BUEHRING

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INVENTOR(S)	(72):	BUEHRING, PETER
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Description /1*

[0001] The invention concerns a transmitter for a two-wire, differential data bus on which a dominant state can be impressed by means of the transmitter in an active state of the transmitter, and which transmitter is in a recessive state when all transmitters connected to the data bus are in a passive state.

[0002] Transmitters of this kind, for example, for the so-called CAN data bus, are distinguished by the fact that in their active state, in which they impress the dominant state on the data bus, one line of the data bus is set at a high level and the other line of the data bus is set at a low level. If this takes place simultaneously, there will be hardly any electromagnetic radiation since then the radiation of one bus line is compensated by the radiation of the other bus line having the reverse sign. However, this ideal state cannot actually be achieved since, in particular, the transistors that are used for switching the signals to the data bus are not ideal. This in turn has the result that, in particular when the active state or the defined level on the two data bus lines is switched on and off, there is electromagnetic radiation through the lines of the data bus.

[0003] In the case of some known transmitters, an attempt is made to reduce the radiation by dividing the terminating resistors of the data bus and bringing the junction point between the divided

*Claim and paragraph numbers correspond to those in the foreign text.

terminating resistors to a reference potential. This does indeed reduce the radiation, but it is still high enough to have a possibly disturbing effect.

[0004] The object of the invention is to improve a transmitter of the type described in the opening paragraph so that there is a further reduction of the electromagnetic radiation at the time of switching the states.

[0005] This object is achieved by providing the transmitter with a capacitor and switching means, by which the capacitor can be alternatively connected with an electric source or between the two data bus lines, and by having the switching means charge the capacitor by means of the electric source during times in which the transmitter is in a passive state, and connect the capacitor between the two data bus lines during times in which the transmitter is in an active state.

[0006] In contrast to known transmitters, in which a voltage source is directly connected to the lines of the data bus in order to impress the dominant state on the data bus in the active state, the invention makes use of a capacitor which is connected to the two data bus lines during the active state phases of the transmitter. Now, it now longer matters if the two electronic switches, by means of which the capacitor is connected to the data bus, have equal switching characteristics. In fact, at the instant when the capacitor is connected to the two lines of the data bus by the switching means,

the voltage on the two lines of the bus is exclusively defined by the current which flows through the capacitor and not by a potential of the voltage source; rather in the transmitter according to the invention, the capacitor has a floating potential. The result is that there is only minimal electromagnetic radiation, even when the two terminals of the capacitor are not connected exactly simultaneously to the data bus lines.

[0007] During those times in which the transmitter is in the passive state, the capacitor is charged by means of an electric source, for example a voltage or current source. Thus, in the case of a transition from the passive state to the active state, the capacitor is disconnected from the voltage source and instead of this is connected to the two data bus lines. Vice versa, in the case of a transition from the active to the passive state, the capacitor is disconnected from the data bus lines and instead of this is connected to the electric source.

[0008] Thus it is possible to use very simple means in order to obtain greatly reduced electromagnetic radiation at the time of switching between the two states.

[0009] An embodiment of the invention according to Claim 2 provides electronic switches in the switching means, two of which switches in each case are provided for connecting to the voltage source and for connecting to the two data bus lines. Advantageously, transistors, preferably DMOS transistors as are provided according to

Claim 5, are used as electronic switches in a further embodiment of the invention. DMOS transistors have a low internal resistance in the active state, so that switching the capacitor alternatively to the voltage source or the data bus lines can be performed with low transition resistances.

[0010] In a situation in which the transmitter operates incorrectly, the case might occur where the transmission of a dominant bit is constantly attempted, which is actually not in accordance with the transmission standard. In this case, the capacitor would represent a high capacitive load on the data bus lines. In order to avoid this, it may be advantageous to provide two diodes as defined in Claim 6, in order to prevent the capacitor from acting as a capacitive load on the data bus lines.

[0011] When DMOS transistors are used as electronic switches, in accordance with Claim 7 it may be advantageous to provide two further diodes, which current paths are opened via the DMOS transistors in the case of a short circuit, therefore in the case where one or both lines of the data bus diodes are short-circuited against reference potential. This is prevented by the two additional diodes as defined in Claim 7.

[0012] In accordance with a further embodiment as defined in Claim 8, a further DMOS transistor, which is connected parallel to the DMOS transistor that connects the capacitor to that data bus line which has a high level in the dominant state, is connected parallel

to a fifth electronic switch (20) made as a DMOS transistor in such a way that this transistor can be switched on even in the case of a short circuit of this line (1) of the data bus. In the case of a short circuit of that data bus line which has a high level in the dominant state, the DMOS transistor connecting this line to the capacitor can no longer be switched on under certain circumstances. It is advantageous to provide the fifth transistor in order to be able to connect the line to the capacitor even if such a disruption exists.

[0013] Since the electronic switches for switching the capacitor are, in principle, to be connected either to the voltage source or to the two data bus lines in nearly similar states, as is provided according to an embodiment as defined in Claim 9, it is advantageous to provide only one control signal which is, however, to be slightly delayed for both groups of electronic switches.

[0014] In particular it is advantageous to provide the data bus transmitter according to the invention for a CAN bus (ISO 11898); all requirements for the bus, respectively for the properties of the transmitter, are fulfilled, although the minor electromagnetic radiation described above is produced.

[0015] A specific embodiment of the invention is described in greater detail below with reference to the single figure of the drawing.

[0016] The figure shows a circuit diagram of a transmitter according to the invention for a CAN data bus in accordance with ISO 11898. The data bus, which is two-wired and differential, is represented in the figure by two junction points 1 and 2 which represent an imaginary extension of two lines of a data bus. The first line 1 is indicated as CAN_H in the figure, this is the line that has a high level in a dominant state of the data bus. The second line 2, which is designated as CAN_L in the figure, is the line that has a low level in the recessive state of the data bus.

[0017] In the example according to the figure, the terminating resistor of the data bus is divided into two parts. Thus, a first terminating resistor 3 and a second terminating resistor 4 are provided, the junction point of which is connected via a capacitor 5 to a reference potential 0. It is possible to obtain a reduction of the electromagnetic radiation as a result of the division of the terminating resistor. However, this reduction is not so strong that problems resulting from the electromagnetic radiation can no longer appear. Therefore, further precautions are taken in the transmitter according to the invention in order to reduce this electromagnetic radiation.

[0018] For this, a capacitor 6, which can be alternatively connected either to a voltage source 11 or to the two lines 1 and 2 of the data bus by switching means 7, 8, 9, and 10 alternatively, is provided.

[0019] In the embodiment according to the figure, the switching means 7, 8, 9, and 10 are made as DMOS transistors that have the advantage that they have a low resistance in the active state.

[0020] Therefore, a p-channel DMOS transistor 7 is provided, the source terminal of which is connected to the positive terminal of the voltage source 11, and the drain terminal of which is coupled to a first pole of the capacitor 6. The source terminal of the second DMOS transistor 8, which is of the n-channel type, is coupled with the negative terminal of the voltage source 11 and reference potential. Its drain terminal is coupled with the second pole of the capacitor 6. Each of the two gate terminals of the DMOS transistors 7 and 8 is coupled with a voltage source 12 and 13, which sources supply control signals used for switching the DMOS transistors 7 and 8.

[0021] If the two DMOS transistors 7 and 8 are switched on by means of the voltage sources 12 and 13, respectively by the control signals supplied by these sources, the capacitor 6 is charged by means of the voltage source 11. This is performed during those times in which the transmitter is in a passive state, i.e. therefore in which the transmitter does not impress a dominant state on the data bus.

[0022] The two further third and fourth DMOS transistors 9 and 10 provided as switching means in each case have their source terminal coupled to the two poles of the capacitor and their drain terminals coupled to the two lines 1 and 2 of the CAN data bus. The

third DMOS transistor is of the p-channel type, and the fourth is of the n-channel type. Also these DMOS transistors can be switched to the active state by means of voltage sources 14 and 15 which supply control signals. The two DMOS transistors 9 and 10 are actively switched during those times in which the transmitter is in an active state, in which it impresses a dominant state on the data bus.

[0023] It is essential here that the capacitor 6 be alternatively connected either to the voltage source 11 by means of the DMOS transistors 7 and 8 or to the data bus lines 1 and 2 of the CAN data bus by means of the DMOS transistors 9 and 10. The capacitor 6 must never be connected simultaneously to both the voltage source 11 and the data bus.

[0024] As already mentioned above, the capacitor 6 is charged by means of the voltage source 11 when the transmitter is in the passive state. Then the transistors 7 and 8 are switched on and the transistors 9 and 10 are switched off. Then if the transmitter is to be shifted to the active state and a dominant state is to be impressed on the data bus, the transistors 7 and 8 are disconnected and, subsequently, the transistors 9 and 10 are switched on. The charged capacitor 6 is then connected to the data bus and impresses a dominant state on this data bus. In this case the two lines 1 and 2 of the data bus are not coupled with a fixed potential, as is the case in solutions according to the prior art. Rather, the capacitor has a floating potential and the voltage of the two data bus lines 1

and 2 is exclusively determined by the current which flows through the capacitor 6. The result of this is that there is also no disturbing electromagnetic radiation through data bus lines 1 and 2 when they are connected, even when DMOS transistors 9 and 10 have different switch characteristics.

[0025] Normally, a dominant state is impressed on the data bus only during fixed time phases during which the charge of the capacitor 6 is sufficient to impress the dominant state on the data bus. In the case of failure, an attempt could be made to impress a dominant state on the data bus during longer phases, which is not allowed in accordance with the CAN protocol. The capacitor can maintain the dominant state only for a limited time. However, the capacitor 6 then would represent a capacitive load between the two data bus lines 1 and 2. In order to prevent this, a first diode 16 and a second diode 17, which are connected between the capacitor 6 and the two data bus lines 1 and 2, are provided. The anode side of the first diode 16 is connected to a first pole of the capacitor 6 and the anode side of the second diode 17 is connected to the second line 2 of the data bus. The result of this is that, even in such a case of defective operation of the transmitter, the capacitor 6 does not appear as a capacitive load for the data bus, respectively its lines 1 and 2.

[0026] Due to interference signals on the data bus lines, which may be caused, for example, by short circuits or electromagnetic

radiation, the potentials of the two data bus lines could be higher than the potential of the positive pole of the voltage source 11 or lower than the potential of its negative pole. If such a case occurs during the active state of the transmitter, in which the DMOS transistors 9 and/or 10 are switched on, the potentials on the capacitor 6 approximately correspond to those of the data bus lines. A third diode 18 and a fourth diode 19 are provided in order to prevent the situation where no current can flow between the capacitor 6 and the voltage source in this case, in spite of the potential difference and the internal diodes of the DMOS transistors 7 and 8. The diode 18 is connected between the two DMOS transistors 7 and 9 and its anode is coupled with the positive pole of the voltage source 11. The diode 19 is connected between the two DMOS transistors 8 and 10 and its anode side is coupled with the second line 2 of the CAN data bus.

[0027] Furthermore, a fifth DMOS transistor 20 is provided, which is of the n-channel type and is connected in parallel with the third DMOS transistor 9, and which is coupled on the source side with the first line of the CAN data bus and on the drain side with the first pole of the capacitor 6. The gate of this fifth DMOS transistor 20 is controlled by means of the current source 15, which in the active state of the transmitter actively switches the DMOS transistor 10.

[0028] By means of this fifth DMOS transistor 20 it is achieved that, in the case of a short-circuit of line 1 (CAN_H) to the reference potential, it is possible to connect this line 1 to the capacitor by means of the fifth transistor 20. Namely, in the case of such a short-circuit, the p-channel MOSFET 9 can no longer be switched on since its drain connection with line 1 is already connected to ground and it would require a negative gate-source voltage in the switched-on state (i.e. with source=drain), but no voltages which are more negative than the reference potential are available.

[0029] Therefore, the redundant n-channel MOSFET 20 is used parallel thereto, which in the normal case can generally not be switched on correctly, because in the normal case CAN_H (its source connection) bears a too positive signal, but in the special case of CAN_H=0V because of short-circuit the transistor 20 can be switched on and take over the function of the transistor 9.

[0030] In summary, in the normal case transistor 9 can be switched on and transistor 20 can be switched on only conditionally, while in the short-circuit case CAN_H=0V transistor 20 can be switched on and transistor 9 can be switched on only conditionally. The MOSFET which can be switched on only conditionally is either switched off when it should be off or it is switched on when it should be on, or it is not switched on although it should be switched on. However, it does not disturb the operation.

[0031] In the presentation according to the figure, altogether four voltage sources 12, 13, 14, and 15, which supply the control signals, are provided for the four DMOS transistors 7, 8, 9 and 10 used as switching means and for the possibly advantageously provided DMOS transistor 20. This generation of the control signals can be clearly simplified by providing only one control signal for controlling all of these DMOS transistors. However, in the case of a transition of the transmitter from the active to the passive state here, the control signal is to be delayed before it is fed to the two DMOS transistors 7 and 8, and in the case of a transition of the transmitter from the passive to the active state, the control signal is to be delayed before it is fed to the other two DMOS transistors 9 and 10. The result is that the capacitor 6 is initially separated from the voltage source and then first connected to the data bus, or, vice versa, it is first separated from the data bus and then connected to the voltage source.

[0032] If a delay of this kind is used, one control signal is sufficient, so that further simplification is obtained.

[0033] In summary, it can be stated that, as a result of using the capacitor, which is alternatively charged by the voltage source or connected to the data bus, the electromagnetic radiation can be reduced during those times in which there is a transition from the active to the passive state of the transmitter, or vice versa. This is achieved by not having a fixed potential impressed on the two

lines 1 and 2 of the data bus in the active state of the transmitter, but by connecting them to the capacitor 6, which has a floating potential. In this case the voltage in data bus lines 1 and 2 is essentially determined only by the current that flows through the capacitor 6.

Patent Claims

1. A transmitter for a two-wire, differential data bus on which a dominant state can be impressed by means of the transmitter in an active state of the transmitter, and which is in a recessive state when all transmitters connected to the data bus are in a passive state, wherein the transmitter is provided with a capacitor (6) and switching means (7, 8, 9, 10), by which the capacitor (6) can be alternatively connected with an electric source (11) or between the two data bus lines (1, 2), and the switching means (7, 8, 9, 10) charge the capacitor (6) by means of the electric source (11) during times in which the transmitter is in a passive state, and connect the capacitor (6) between the two data bus lines (1, 2) during times in which the transmitter is in an active state.

2. The transmitter according to Claim 1, wherein the switching means (7, 8, 9, 10) have a first and a second electronic switch (7, 8), by which the capacitor (6) can be connected to both poles of the electric source (11), and a third and a fourth electronic switch (9, 10), by which the capacitor (6) can be connected to the two data bus lines (1, 2).

3. The transmitter according to Claim 1, wherein a voltage source (11) is provided as electric source.

4. The transmitter according to Claim 2, wherein transistors (7, 8, 9, 10) are provided as electronic switches.

5. The transmitter according to Claim 3, wherein DMOS transistors (7, 8, 9, 10) are provided as transistors.

6. The transmitter according to Claim 1, wherein a first diode (16), which is coupled between a first terminal of the capacitor (6) and the first line (1) of the data bus, and a second diode (17), which is coupled between a second terminal of the capacitor (6) and the second line (2) of the data bus, are provided.

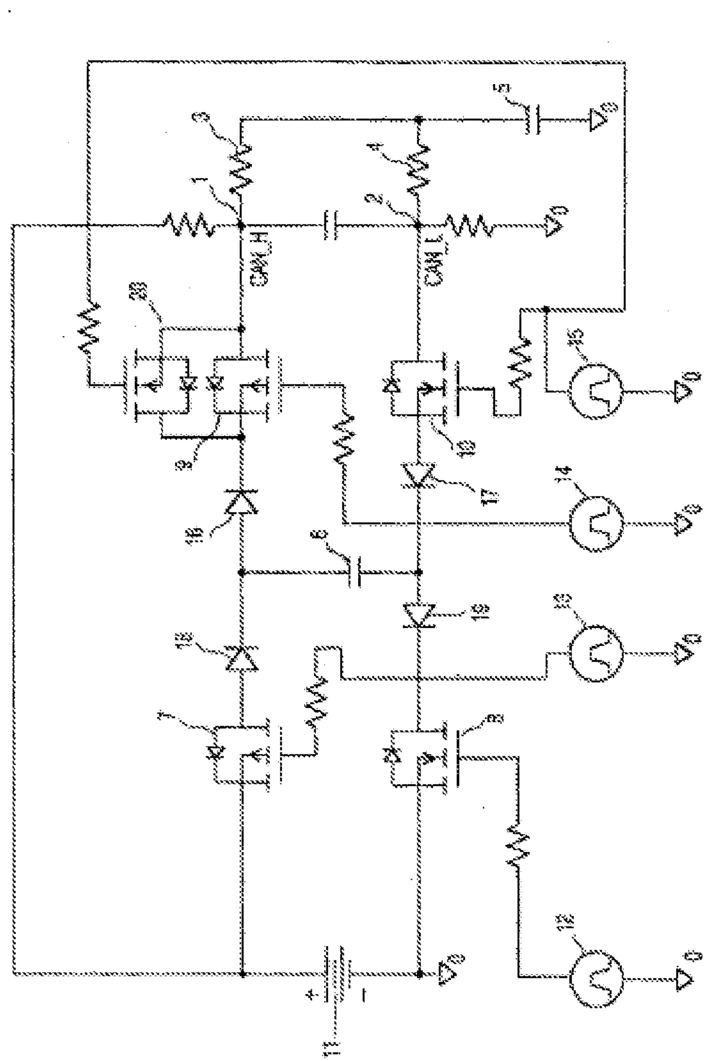
7. The transmitter according to Claim 5, wherein a third diode (18), which is coupled between the voltage source (11) and the first line (1), and a fourth diode (19), which is coupled between the voltage source (11) and the second line (2) of the data bus, are provided.

8. The transmitter according to Claim 5, wherein a fifth electronic switch (20), made as a DMOS transistor, can be connected in parallel to the third electronic switch (9) made as a DMOS transistor, by means of which the capacitor (6) can be connected in parallel to that line (1) of the data bus which has a high level in the dominant state, in such a way that this switch is connected even in the case of a short circuit of this line (1) of the data bus.

9. The transmitter according to Claim 2, wherein a control signal for controlling the electronic switch (7, 8, 9, 10) is provided, the control signal being delayed before being fed to the first and the second electronic switches (7, 8) in the case of a transition of the transmitter from the active to the passive state,

and the control signal being delayed before being fed to the third and the fourth electronic switch (9, 10) in the case of a transition of the transmitter from the passive to the active state.

10. The transmitter according to Claim 1, wherein a CAN bus is provided as a data bus.


CAN_H
CAN_L